



CHAPTER 2

Products and Markets

The demand for metal components is expected to change as new markets and products emerge and others disappear. The metalcasting industry will need to anticipate emerging industry and consumer needs and provide innovative products that are superior in quality and competitively priced. New processes will be needed to cast metal components that meet the demanding material specifications and designs of new products. Learning how to meet the technical demands for new products and markets will be essential to the future viability of the metalcasting industry.

Current Situation

U.S. metalcasting industry shipments in 1996 totaled about 13.4 million tons with a value exceeding \$23 billion. The major markets served by the metalcasting industry, shown in Exhibit 2-1, include motor vehicles (particularly passenger vehicles and light trucks but also medium and heavy trucks); industrial machinery; farm, construction, railroad, and transportation equipment; pipes and fittings; engines and turbines; pumps; compressors; and electric power equipment. Automobiles and other transportation equipment currently consume 50 to 60% of all castings produced in this country.

The U.S. foundry population has declined by about one-third over the last 20 years to about 3,000 foundries, largely as a result of foreign competition and increasing imports of goods containing castings. Another factor has been the cost of legislative compliance, which has become too burdensome for some marginally performing foundries to continue operations. Correspondingly, total industry production has decreased during this same time period -- although by a smaller percentage -- and the industry has lost about 9 million tons of capacity.

Exhibit 2-2 shows the forecasted casting capacity and demand/supply ratios predicted for 1997. Based on planned closings of facilities and planned expansions, the usable metalcasting capacity is estimated at 17,682,000 tons, the first increase of capacity since 1981 and a positive sign for the industry.

Approximately 13.8 million tons of castings with a value of about \$25.2 billion are expected to be produced in 1997, a 2.7% increase over 1996. This upward swing is expected to continue at least through 1999. Although total shipment growth is modest, it indicates the metalcasting industry is beginning to follow the general trends in the overall economy.

Trends and Drivers

The metalcasting industry is in a state of change. Some segments of the industry are mature or declining, while others are emerging or transforming themselves as new industries. The mature ferrous sectors are

Exhibit 2-1. Major Markets Served by the Metalcasting Industry - 1994		
Market	Ferrous (%)	Non-Ferrous (%)
Motor Vehicles	28	43
Ingot Molds	20	0
Pipe	20	0
Industrial Machinery	14	15
Farm Equipment	9	0
Railroad	5	0
Construction	4	5
Transportation	0	13
Electric Power	0	24
TOTAL	100	100

Source: *A Technology Vision and Research Agenda for America's Metalcasting Industry*, American Metalcasting Consortium, February 1995.

Exhibit 2-2. Forecasted Casting Capacity and Demand Supply Ratios - 1997		
Metal	Capacity (000 tons)	Demand/Supply (%)
Iron	12,665	80
Steel	1,761	74
Aluminum	2,114	77
Copper-Base	400	75
Magnesium	40	78
Zinc	430	82
Other Nonferrous	62	65
Investment Casting	210	79
TOTAL	17,682	79

Source: *1997 Metalcasting Forecast & Trends*, The American Foundrymen's Society, 1996.

most susceptible to low-cost foreign producers because of the lower-value-added products they manufacture. These sectors are characterized by flagging demand for their products and little or no development of new markets. The emerging sectors, including the non-ferrous metalcasters, typically use newer processes in the manufacture of higher-value-added products, and are continuing to develop and exploit new markets. These casters in good position for the future, when castings are predicted to have more complex structural requirements, with higher performance castings replacing what once were assemblies. Some additional market trends are shown in Exhibit 2-3.

Several major factors affect the demand for specific castings. These include:

- shifts in the types of metals or metalcasting processes used for a given product
- the replacement of castings with non-cast components
- the shrinking materials requirements of lighter-weight automobiles and other transportation equipment
- continued loss of domestic castings markets to foreign metal casters

The majority of the loss in casting markets is attributed to a drop in the production of gray iron castings, which are **losing market share to other metals** (such as aluminum) as well as plastics. The continued loss of gray iron tonnage to aluminum in motor vehicles is expected to drop the average weight of gray iron per unit produced to 345 pounds in 1996 and 215 pounds in 2005. The market for ductile iron castings has increased significantly over the past 15 years, in part because of a shift toward the use of these castings instead of malleable iron, steel castings, and steel fabrications. Concurrently, U.S.-produced steel castings and malleable iron castings have lost portions of their markets. However, a new trend toward the conversion of suspension and brake parts from ductile iron to aluminum is expected to decrease ductile iron demand in the automotive market.

The loss in casting markets has also occurred with the **replacement of castings with non-cast components**. As mentioned above, plastics have replaced gray iron castings in many applications. For example, plastic pipe is now used in many iron-pipe applications. Plastics and wrought copper alloys are also substituting for brass and bronze castings in the plumbing market, decreasing the demand for these castings. Another example is the use of composite materials for structural components in special applications, which is cutting into the castings market.

The **downsizing of end products** has also reduced demand for castings in some markets. For example, the overall average weight of automobiles has decreased over 30% in the past 15 years. Die casters, half of whose business is generated by the automotive industry, are greatly influenced by weight reduction in vehicles. Vehicle downsizing has resulted in the substitution of magnesium for die-cast zinc trim, reducing production levels to about one-third of previous levels.

The market for many castings has also been penetrated by **foreign competition** from assembled components that contain castings, especially in the automobile, steel, and machine tool industries. Specific markets that have been lost to foreign competition include steel and iron valves (to China, Taiwan, and India), steel construction parts (to South Africa), municipal iron (to India), aluminum die castings (to Korea), gray iron engine/compressors (to Brazil), malleable iron fittings (to Thailand), and gray iron power transmissions (to India).

Exhibit 2-3. Metalcasting Market Trends

- **Production of aluminum, steel, and ductile iron castings is predicted to increase** over the next ten years; production of gray iron castings (currently the largest segment of the industry) is predicted to decrease because of competition from abroad and from other metals and materials.
- **The markets for aluminum and magnesium castings have been expanding**, in part because of the substitution for ferrous castings in the automotive sector. Demand for aluminum components, especially driven by weight reduction needs in the automotive sector, is expected to increase substantially. Corporate Average Fuel Economy (CAFE) standards will require further weight reduction in cars.
- **The use of magnesium and titanium for castings continues to grow** in acceptance, particularly in the automotive and aerospace markets.
- **The use of aluminum-lithium alloys as investment casting materials holds promise** in opening new markets in the aircraft industry, where it could reduce the structural weight of aircraft by replacing wrought products.
- **Rebuilding the aging U.S. infrastructure provides a huge, continuing market** for iron and steel castings for decades to come.

Performance Targets

The metalcasting vision, *Beyond 2000: A Vision for the American Metalcasting Industry*, outlines three challenges for metalcasting market development:

- C Recapture 25 to 50% of lost markets
- C Improve market share in current markets by 10%
- C Increase the rate of new market development

In terms of recapturing lost product areas with metalcasting products, many past markets have been lost to more competitive materials or to redesigned products that made cast products obsolete. While some lost markets may be regained, it will likely be with new applications and advanced products that may not resemble the old ones.

Technology Barriers

Metalcasters have an opportunity to build share in existing and emerging markets by considering the wide span of potential cast products and approaching them with new process and technology capability. However, to accomplish market expansion several types of barriers must be overcome, barriers that exist for both customers and producers. Many of these barriers address market structure, information, and knowledge issues between customers and producers that must be resolved before cast metal products can have a significant impact in emerging markets. As shown in Exhibit 2-4, areas that present the greatest barriers for expanding products and markets include:

- Design Tools and Processes

- Standards
- Customer Requirements
- Designer/Customer Knowledge
- Infrastructure
- Education

Lack of adequate **design tools and processes** is a key issue. Design tools exist for foundry designers but there are no adequate tools to help functional designers within the various customer industries such as automotive and aerospace. There is also no concurrent engineering process that is robustly applied across the industry today; product design and casting design are sequential processes that result in long lead times and suffer from a lack of interaction between the producer and the supplier. Another barrier is the lack of adequate design-for-manufacturing tools that are easy to use and access.

The lack of **standards** for castings that would aid both customers and producers limits opportunities for cast products. The available property and performance data on materials and castings vary widely, are not standardized, and are not contained in a single source. In addition, many new alloys do not appear in any national standard or construction code. This lack of standardized information on the characteristics of various alloy hurts castings ability to be considered for new applications. Many casting users cannot give quick approval to any casting alloy for safety reasons. Parts cannot be cast with new alloys for which detailed technical data and testing documentation are not available. The exclusion of many alloys from national standards and construction codes has created a barrier to wider use of these materials. In addition, the United States is not using international standards, putting it at a disadvantage vis a vis foreign producers.

Understanding **customer requirements** presents the biggest challenge to market development efforts. Both technical and marketing barriers prevent casters from fully communicating to customers the advantages that can be gained from using castings in products. For example, the customer often does not realize that a casting may be produced at a lower cost than alternatives.

Many foundries are small operations that do not have the staff or financial resources to spend sufficient time understanding customer needs, educating designers about process choices, and tracking future product trends. Castings are also seen as a manufacturing issue and not a primary design issue. This is unfortunate because proper consideration of casting in the design phase could help reduce the cost and increase the quality and integrity of the customer's product.

Several **knowledge barriers**, particularly among customers, prevent acceptance and expansion of castings' markets. Customers are very averse to risk; they understand how a wrought product will function in a design environment but they may not understand the capabilities and design issues associated with castings. Key individuals within the customer companies -- including the designers, purchasing agents, release engineers, and reliability engineers -- lack confidence in castings and are not accustomed to the time required for tooling and testing. With few exceptions, most end-users are completely unaware that castings are a part of the product they have purchased.

The current **supply and market infrastructure** also presents an organizational barrier to expansion of casting applications. Metalcasters are typically second- or third-tier suppliers and do not provide their products directly to the companies that will incorporate them into the end product. When an original equipment supplier (OEM) requires a casting, they typically turn to a machine shop or some other type of value-added supplier. The supplier, in turn, will go to a foundry for its casting requirements. The casters typically do not deliver their product directly to the OEM; they deliver their product to a value-added, first-

tier supplier who then processes it further before delivering the required part, component, or subassembly to the OEM customer.

Exhibit 2-4. Major Technology Barriers in Market Development (Most Critical Barriers Boldfaced)	
AREA	BARRIERS
Design Tools and Processes	<p>Absence of concurrent engineering</p> <ul style="list-style-type: none"> - gap between what is expected and what is delivered <p>Casting designs generally take longer than alternatives in concept development</p> <p>Lack of a common, easy access base of design information related to metalcasting</p> <p>No design-for-manufacturer tool that is easy to use and access</p> <p>The commonly used “design by analogy” method limits ability to consider major changes in basic design features</p> <p>Many castings not optimally designed for functionality and castability</p> <p>Difficult to convert a prototype design already approved as a machined-part fabrication to a casting</p> <p>Lack of intermediate shops between castings and finished product (e.g., machining, heat treating)</p> <p>Optimizing for internal productivity may not optimize for customer needs</p> <ul style="list-style-type: none"> - mixing and unraveling is inefficient <p>Production control systems are inadequate for casting</p> <ul style="list-style-type: none"> - MRP systems do not work in reverse
Standards	<p>U.S. is not using international standards</p> <p>Standards do not exist for information exchange (customer/producer)</p> <p>Performance database standards do not exist</p> <p>New component applications seldom considered as castings in part because of the lack of standardized design data</p> <p>Testing required to include alloys in U.S. standards and construction codes is extensive and costly</p> <p>Industry has not captured the logic inherent in metalcasting design choices</p>

Exhibit 2-4. Major Technology Barriers in Market Development
(Most Critical Barriers Boldfaced)

AREA	BARRIERS
Customer Requirements	<p>Inability to adequately identify future customer needs and therefore predict technology</p> <ul style="list-style-type: none"> - company size makes this difficult <p>View that castings are a manufacturer issue, not a primary design issue</p> <p>Inability to effectively market castings</p> <p>Customer drives demand, but casters do not understand the customer requirements</p> <p>Systems are not designed to make customer deliveries</p> <ul style="list-style-type: none"> - casting traceability <p>Delivery time is too long</p> <p>Customers are demanding higher quality and more value-added services</p> <ul style="list-style-type: none"> - quality of castings is sometimes perceived as being insufficient
Designer/ Customer Knowledge	<p>Design engineers lack knowledge of existing methods</p> <p>Lack of acceptance by users because of lack of knowledge about castings</p> <p>Final customer is completely unaware of castings in their product</p> <p>Customers are risk-adverse and lack confidence in castings</p> <ul style="list-style-type: none"> - designers - release engineering - purchasing agent - reliability engineering <p>Customers are not used to the time it will take for tooling, testing, etc.</p> <p>Customer underutilization of casting geometry to make better parts that are more castable</p>
Infrastructure	<p>Foundries are not tier-one suppliers to original equipment suppliers (OEMs)</p> <p>Transition from a sellers' market to a buyers' market</p> <p>Industry is often unable to respond quickly to emerging market opportunities</p> <p>Cost of start up, tool, pre-production, and testing are unique to themselves</p> <ul style="list-style-type: none"> - not part of the metalcasting industry - metalcasting industry expects customer to pay for it <p>Movement of existing tooling from foundry to foundry has been more prevalent than an emphasis on identifying and developing new applications</p>
Education	<p>Inability to educate/attract new employees at the high school level</p> <p>Inability to attract new engineers into metalcasting industry</p> <p>Different research capabilities will be required to solve emerging problems</p>

Limited **education** appears to be one of the culprits behind the lack of understanding of metalcasting processes and properties. The industry has been unable to attract and educate new employees at both the

college and high school level. Unlike some technical areas, instruction in metalcasting processes and properties is not incorporated into the general engineering curriculum, and students often are not exposed to this field of study.

Research Needs

Research required to overcome technical and market barriers should be characterized with sufficient detail to help focus the research community in solving technical problems but with a broad enough scope to encourage innovative approaches to complex problems. Research will be required in the near term (0 to 3 years) to improve many existing tools and processes, in the mid term (3 to 10 years) to meet more complex needs and pursue new markets, and in all time frames (0 to 10+ years) for ongoing research that will produce benefits in several time periods (see Exhibit 2-5).

Research in **design tools** will focus on improving tools and deploying them rather than considering all the new tools that might be required. For example, a design-for-manufacture tool that is easy to use—possibly even web-based—would enable a design engineer to specify product attributes and have the design tool determine how metalcasting can be applied to the product in much the same way that the electronics industry uses design tools to meet circuit board specifications. A tool that would enable concurrent engineering throughout the production system and reduce lead times would be more responsive to customer needs. In the mid term, a more comprehensive design tool that would allow a designer to move from a part design to a casting design would streamline the design process and clarify design choices. There is also a need to develop a feature-based design tool that considers geometry and its relationship to physical and mechanical properties.

Research to improve **products and processes** must focus on developing ways to demonstrate the quality and value of cast products. Part of this will be accomplished by working with customers and end consumers to understand how they judge quality, and to demonstrate the cost and quality of metalcasting versus other metal forming processes. Processes must be developed to make products more consistent and their performance more predictable. For example, improved methods must be developed to predict the amount of contraction that occurs in patternmaking. In the mid term, tools must be developed to reduce lead times in the metalcasting industry. Rapid prototyping, for example, can greatly reduce the time needed to design a new casting. It will be important to coordinate the various research efforts underway to reduce lead times.

Perhaps the most critical need is in the area of **market transformation**. Both research and market push is needed to change the way metalcasters interact with their customers and the product and services they provide. The transformation of foundries to first-tier supply status to OEMs has the potential to substantially change the way customers perceive and use castings. By accepting a more prominent role with the customer, casters will ensure that the full value of castings in products and components is credited to the metalcasting industry rather than to a machine shop that might alter or change the cast product. There is also a near-term need to do a better job analyzing the demand for castings in future products. The ability to foresee changes or identify emerging material and part requirements is vitally important to the industry.

Casters must also work to help the customer to better assimilate metalcasting technology and design approaches. Most of the design community thinks in terms of wrought products, viewing standards, properties, and design processes from the perspective of a wrought producer. Metalcasters need to communicate cast metal properties in a way that a designer will understand.

Finally, in the **education and standards area**, metalcasting should become better integrated into the engineering curriculum at colleges and universities. In the electronics area, for example, all electrical engineers are taught advanced signal integrated circuits whether they plan a career in designing circuit boards or designing large utility power systems. One of the ways that metalcasting can become more accepted in engineering curriculums is to make tools (e.g., design-for-manufacturing software) more available to engineering programs. Component designers also need to be made more aware of the capability of castings. One way to help accomplish this is to develop product definition and quality standards.

Exhibit 2-5. R&D Needs in Products and Markets by Time Frame

(**k** = Top Priority; **M** = High Priority; **F** = Medium Priority)

Time Frame	Design Tools	Product and Process Improvements	Market Analysis and Transformation	Education and Standards
NEAR (0-3 Years)	<p>F Develop tools to enable concurrent engineering throughout the production system</p> <ul style="list-style-type: none"> - must be ready to act - increase responsiveness to customer need <p>F Develop design-for-manufacture tool that is easy to use (possibly web-based)</p> <p>Develop robust, interoperable analysis tools for the metalcasting industry</p> <p>Develop better solid model casting design tools</p> <p>Advance the integration of part/tool design and process variable specification</p>	<p>M Develop ways to demonstrate quality and value of metal casting products</p> <p>M Develop improved methods to predict patternmaking contraction</p>	<p>k Develop methods to encourage/systematize concurrent engineering partnerships within metalcasting industry</p> <ul style="list-style-type: none"> - standardize specification for efficient transfer of information <p>Conduct gap analysis among customers</p> <ul style="list-style-type: none"> - who is going to help the small founders <p>Determine how castings can be marketed effectively</p> <p>Analyze the demand for major cast products</p> <ul style="list-style-type: none"> - change product design or change the casting process 	
MID (3-10 Years)	<p>M Develop computer design tool to move from a part design to a casting design</p> <p>M Develop a feature-based design that considers geometry and its relationship to</p>	<p>F Develop tools and technologies to reduce lead times in the metalcasting industry</p> <ul style="list-style-type: none"> - coordinate existing work in this area - prototyping - production 	<p>Develop a system to determine and disseminate what the competition is doing</p> <ul style="list-style-type: none"> - database of competitive properties, processes, and costs for competing 	<p>F Determine how to teach metalcasting across the engineering curriculum</p> <ul style="list-style-type: none"> - determine how it happened with computers - make tools readily available

Exhibit 2-5. R&D Needs in Products and Markets by Time Frame (k = Top Priority; M = High Priority; F = Medium Priority)				
Time Frame	Design Tools	Product and Process Improvements	Market Analysis and Transformation	Education and Standards
	physical and mechanical properties - improve visualization of casting geometry in 3 dimensions Develop software to simulate casting processes and casting service under various conditions		materials - expert system to compare the best metalcasting processes against forging and weldment alternatives	Develop standards to change the expectations of castings Develop product definition and quality standards
ALL (0 - 10+ Years)	Develop tools required to turn casting design into production design - work castings into early stages of design - economics must be there	Develop castings for new applications in construction, large structures, transportation equipment, defense hardware, etc.	k Transform founders into tier-one suppliers Develop methods to facilitate and systematize metalcasting design and manufacture	

Potential Government Role

Government involvement in research for metalcasting products and markets has been identified for six areas. Developing design tools that enable concurrent engineering and design-for-manufacturing, while mostly seen as near-term priorities, would be appropriate for government participation. Developing advanced computer design tools that smoothly link part design and casting design is another area where the industry will require government resources and expertise. In product and process improvements, the government can play a key role in helping to coordinate existing research and technologies focused on decreasing metalcasting lead times.

Although specific activities still need to be identified, the government is seen as an important participant in helping to transform metalcasting markets. For example, the transformation of metalcasting companies to become first-tier suppliers to industrial customers will mostly be accomplished by industry. However, the government may have a role in participating in research in selected areas. The government can also help the metalcasting industry in conducting analysis of the demand for cast products.

Linking individual research needs to specific industry performance goals is difficult because there is no clear distinction between whether an activity will aid in expanding a market or in establishing a new one. The identified research needs are fairly generic and can apply to both existing and new market applications. As a general guide, however, activities associated with product and process improvements tend to contribute more to expanding existing product markets. Activities to develop and improve design tools tend to focus on facilitating the use of metalcasting in the development of new products and would contribute greatly to the goal of pursuing emerging markets. Market transformation seeks to change the relationship of

metalcasters with their customers to increase the application and use of cast products. If successful, it will contribute equally to existing and new market expansion.